**AUTOMATED SAFETY SYSTEM FOR GAS LEAKAGE DETECTOR**

By

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FINAL YEAR PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfillment of the Requirements

for the Degree

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

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# CERTIFICATION OF APPROVAL

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Approved:

AP Dr Mumtaj Begam Kasim Rawthar
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
December 2009

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Norita Azrin Shahrulzaman

## ABSTRACT

The main purpose of this project is to achieve a successful working prototype that is capable to detect the presence of gas leakage, which in this case, the Liquefied Petroleum Gas (LPG). The device should also perform automatic response with the implementation of an alarm system and the emergency shut down valve once the leakage has occurred and detected. The essential part of this project is to detect the occurrence of leakage and this is done by comparing the intensity difference of the infrared radiation. Once this condition is true, this will lead to the alarm triggering as well as activating the emergency shut down valve. Further research is especially done to comprehend in some infrared radiation detector knowledge, LPG characteristics, alarm and relay circuits. As a conclusion, this project has given the opportunity for students to integrate theories into solving the problems related with the engineering scope of work.

## ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to AP Dr Mumtaj Begam for her dedication, support and understanding towards me in completing this project. Her ideas, suggestions as well as motivation all have made me inspired and motivated to become a never-give-up person and continuously begin to find efforts in order to achieve the target of this project.

Further gratitude is also expressed to Mr Hairul Azmi, an expert in circuit as well as EAGLE software, for his dedication and willingness to teach me regarding the new knowledge that has never been taught without doing further research.

I also want to thank my parents as well as friends, for their moral support, listening to my problem and failure thus encouraging me t stand up and do something rather that facing the failure continuously.

Without those people involved, I myself could not gain mental strength, motivation, passion and spirit to improvise and achieve the target of this FYP. A millions of thank you to all of them.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Background of Study

Gas detection of a hydrocarbon gas via infrared (IR) absorption requires the absorption of optical energy (IR) by the gas at the wavelength of interest [1]. Different gaseous have different absorption spectrum. In this project, attention will be given to Liquefied Petroleum Gas (LPG) which is an energy source primarily composed of propane and butane. Due to the unique absorption properties of gas to infrared radiation, leakage can be detected by measuring and comparing the IR intensity at both source and detector. In order to enhance the effectiveness of the gas leakage detector, a circuit consisting of an alarm system will be implemented to the prototype to warn users when gas leakage occurs

## 1.2 Problem Statement

In most industries, one of the key parts of any safety plan for reducing risks to personnel and plant is the use of early-warning devices such as gas detectors. These can help to provide more time in which to take remedial or protective action. They can also be used as part of a total, integrated monitoring and safety system for an industrial plant [2]. Rapid expansion of oil and gas industry [3] leads to gas leakage incidents which are very serious and dangerous. Solutions need to be find out at least to minimize the effects of these incidents since gas leaks also produce a significant financial loss [4]. The challenges are not only to design a prototype of the device that can only detect but also automatically respond to it whenever the leakage occurs.

Figure 1: Damage that occurred due to LPG explosion

The Figure 1 above is an example of LPG explosion. Such accident might occur when it is not properly-monitored. In the four-season countries like Russia, the LPG is used as one of the heating sources to warm the citizens' houses during winter. There was no one was in the home at the time of the explosion. "This explosion has raised the roof and blew out the walls of the house, sending debris flying into neighbouring yards. The two-storey house which was owned by Steve Cook, was rendered uninhabitable and its three occupants temporarily made homeless. "[5]

The LPG is also one of the gasses which is difficult to detect by human's limitation of senses. "Cook said that natural gas caused the explosion, but he was unable to detect any gas fumes because a workplace accident had robbed him of his sense of smell. He happened to leave the house to pick up his daughter from school when the house blew up" [5].

## 1.3 Objectives

This project is the continuation based from the previous Final Year Project 2007 will improvise the unsuccessful transmitter circuit of infrared radiation. By the end of this project, student is expected to have built a working prototype which will be able to detect the gas leakage and automatically.

Other than that, student must also add some of the safety actions which are the implementation of alarm system to alert users of the leakage occurrence. The alarm will trigger as soon as the infrared radiation has shown a positive detection when the leakage of LPG had occurred. Due to the trigger of the alarm, the air-valve is also activated to close the pipeline which in this prototype case, the plastic tube acted like one. Once the air valve has fully-closed, an alarm will be disabled.

## 1.4 Scope of Study

The scope of study for this project are :

- ☐ To study on the characteristics of infrared (IR) and Liquefied Petroleum Gas (LPG) : Students need to study on the mechanism of infrared being emitted and absorbed. Since LPG is one of the gases that absorbs IR radiation at certain wavelength, the detection principle can be done by comparing the intensity difference before and after the absorption of the LPG.

- ☐ To understand the working principle of alarm system and design the circuit : Alarm circuit has to be constructed to automatically respond to the occurrence of leakage. Several conditions need to be considered in order to trigger the alarm.

☐ To design a working prototype of gas leakage detection equipped with automatic alarm system :
A successful working prototype consisting of infrared emitter and sensor, alarm circuit and emergency shutdown valve is expected to function very well at the end of this project.

☐ To construct working circuit for infrared transmitter and detector :
Transmitter circuit should be able to transmit infrared radiation at a desired frequency. Appropriate detector circuit need to be find to detect the presence of leakage and trigger the relay circuit

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Infrared Radiation

Infrared radiation is electromagnetic radiation of wavelength which is longer than the visible light but shorter than the radio wave [1]. There are many common sources of radiation emitting infrared such as sunlight, tungsten and lasers. Infrared light has range of wavelengths, just like visible light, which has wavelengths ranging from red to violet. Figure 2 shows that IR light lies between the visible and microwave portions of the electromagnetic spectrum. Infrared radiation is typically produced by objects whose temperature is above 10°K [6].

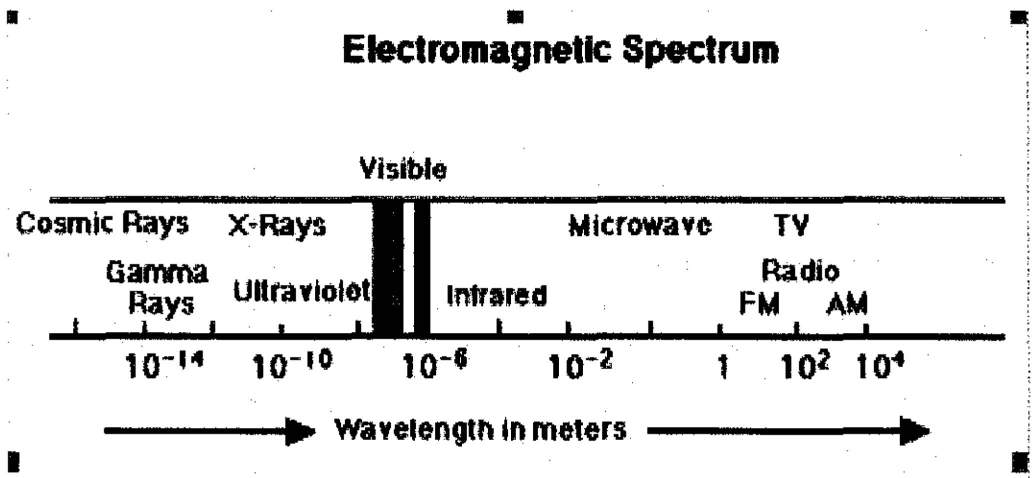


Figure 2 : Electromagnetic Spectrum [7]

## 2.2 Gas Detection Principle by Infrared Absorption

Certain gases in the atmosphere have the property of absorbing infrared radiation. The infrared radiation strikes a molecule such as propane and butane that causes the bonds to bend and vibrate [7]. This is called the absorption of IR energy. The molecule gains kinetic energy by this absorption of IR radiation.

IR radiation does not have enough energy to induce electronic transitions as UV radiation. Absorption of IR is restricted to compounds with small energy differences in the possible vibrational and rotational states [8]

For a molecule to absorb IR, the vibrations or rotations within a molecule must cause a net change in the dipole moment of the molecule. If the frequency of the radiation matches the vibrational frequency of the molecule then radiation will be absorbed, causing a change in the amplitude of molecular vibration [8]. Therefore, the vibrational frequency of the infrared to be matched with the vibrational frequency is around 88THz.

The existing gas leakage detector in the industry is by using the catalyst detector. This new technology provides major advantages over the catalyst detector. Some advantages of using infrared gas detectors are [3] :

1) Immunity to contamination and poisoning.
2) Ability to operate in the absence of oxygen or in enriched oxygen.
3) Ability to operate in continuous presence of gas.
4) Can perform more reliably in varying flow conditions.
5) Even when flooded with gas, will continue to show high reading and sensor will not be damaged.

## 2.3 Liquiefied Petroleum Gas

LPG or LP Gas is Liquefied Petroleum Gas. This is a general description of Propane (chemical formula C3H8) and Butane (chemical formula C4H10), either stored separately or together as a mix [9]. LPG is a mixture of hydrocarbon gases which are propane and butane used as a fuel in heating appliances and vehicles [1]. Propane and butane are gaseous at normal temperature and can be liquefied under low pressure to provide easier packing. The name LPG comes from the fact that these gases can be liquefied at normal temperature by application of a moderate pressure increase, or at normal pressure by application of cooling using refrigeration. LPG comes from two sources. It occurs naturally in oil and gas fields and is separated from the other components during the extraction process from the oil or gas field. LPG is also one of the by-products of the oil refining process.

LPG is used as a fuel for domestic, industrial, horticultural, agricultural, cooking, heating and drying processes. LPG can be used as an automotive fuel or as a propellant for aerosols, in addition to other specialist applications. LPG can also be used to provide lighting through the use of pressure lanterns. The advantages of LPG gases are as follows [9] :

☐ Because of its relatively few components, it is easy to achieve the correct fuel to air mix ratio that allows the complete combustion of the product. This gives LPG it's clean burning characteristics.

☐ Both Propane and Butane are easily liquefied and stored in pressure containers. These properties make the fuel highly portable, and hence, can be easily transported in cylinders or tanks to end-users.

☐ LPG is a good substitute for petrol in spark ignition engines. Its clean burning properties, in a properly tuned engine, give reduced exhaust emissions, and extended lubricant and spark plug life.

- As a replacement for aerosol propellants and refrigerants, LPG provides alternatives to fluorocarbons which are known to cause deterioration of the earth's ozone layer.

- The clean burning properties and portability of LPG provide a substitute for indigenous fuels such as wood, coal, and other organic matter. This provides a solution to de-forestation and the reduction of particulate matter in the atmosphere (haze), caused by burning the indigenous fuels.

Some of the characteristics of LPG are [5] :

- Colourless.
- Odourless.
- Flammable.
- Heavier than air.
- Approximately half the weight of water.
- Non toxic but can cause asphyxiation.

# CHAPTER 3
# METHODOLOGY

## 3.1 Procedure Identification

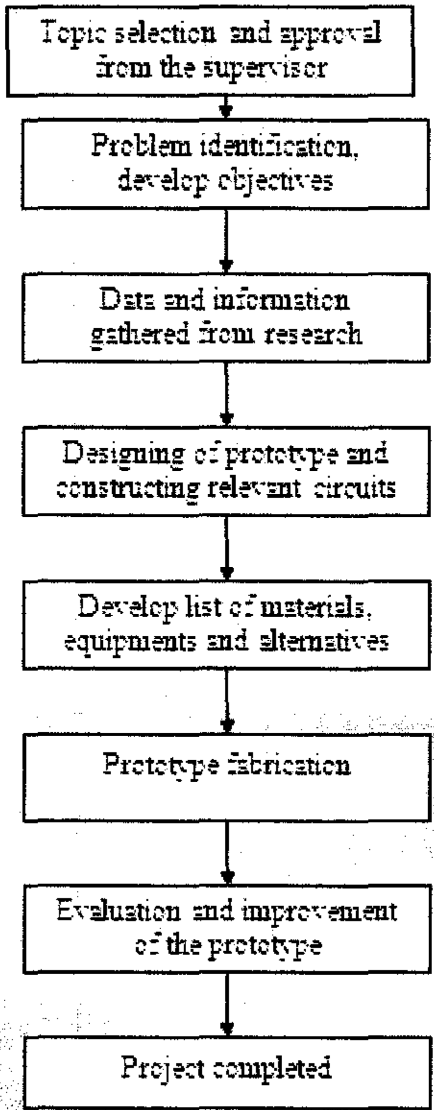


Figure 3: Project Methodology

The Figure 3 shows the sequential step by step procedure to be followed throughout this project. Until now student has reached into the prototype fabrication which is mainly to construct the infrared circuit. Further explanation will be given in the Result and Discussion in the section of Chapter 4.

## 3.2 Illustration of Infrared Gas detection Model

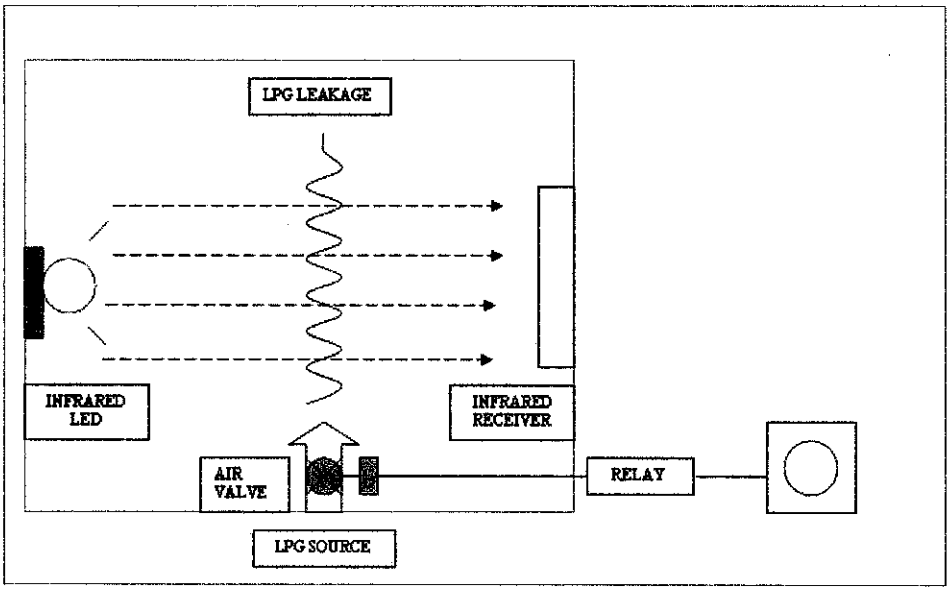


Figure 4: Infrared Gas Detection Model

This project is divided into two parts:

**Part I (Alarm System)**

The first part of this project is to design alarm circuit to be equipped in the prototype. Whenever the presence of gas leakage is detected by the receiver circuit, signals will be sent to the oscilloscope and relay circuit. The alarm system will automatically triggered to warn users of the leakage.

**Part II (Emergency Shutdown Valve)**

Next after the first part, the second part would be the design of the circuit of emergency shutdown valve circuit. The shutdown valve will close the source of gas automatically whenever the leakage occurs to avoid severe consequence from this incident. The relay circuit acts as a switch to turn on the alarm as well as closing the shutdown valve.

## 3.3 Circuit Construction

The study of circuit examples from the previous projects as well as the inventions available in the market have been done in order to choose the most appropriate IR circuit to be implemented in this project. After deciding, the most reliable circuit to be constructed, the simulation is done in PSPICE in order to obtain the rough idea on how the circuit will behave.

### *3.3.1 Transmitter Circuit*

Transmitter circuit will be used as the source of IR radiation in this project. Due to the fact that LPG gases absorbs IR at certain wavelength, the transmitter circuit needs to be designed to transmit desired IR frequency. Theory stated that LPG gases absorb IR radiation at the frequency of 3.4μm [2].

**Frequency = speed of light/ wavelength**..........................................Equation 1

Referring to equation 1 :

Frequency = ( 3.0 x 10^8) / 3.4μm

= 88.2 THz

Therefore, the transmitter circuit should be capable of producing IR radiation at frequency of 88.2 THz. The IR transmitter circuit is constructed with 555 timer circuit

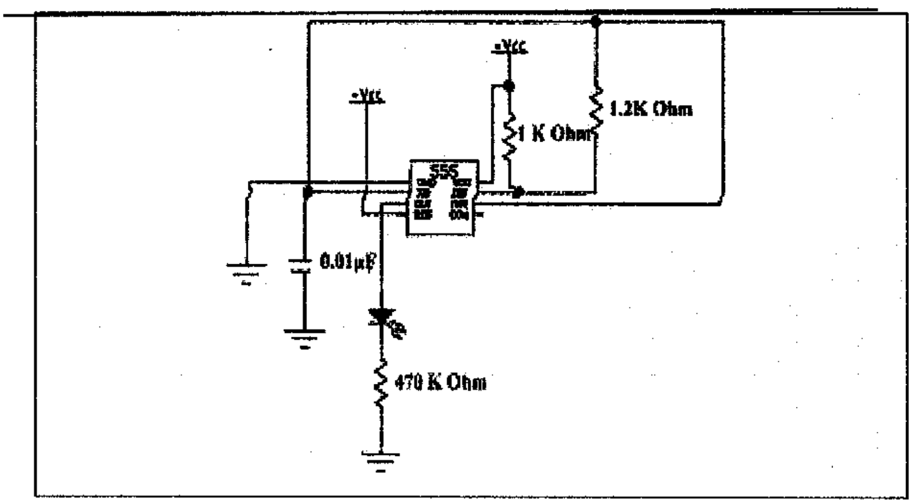


Figure 5 : 555 timer circuit

By using only this timer circuit above, the objective to transmit the IR radiation would not be reached the desired vibrational frequency for the infrared to absorb LPG vapour is greater than the frequency of 555 timer circuit can generate. The 555 timer circuit is indeed having some limitation in frequency generation because it is largely depend on the value of resistor and capacitor. .

### *3.3.2 Receiver Circuit*

A thermopile detector constructed and arranged to receive infrared radiation after the transmission thereof through the gas sampling region and to responsively generate an output signal correlative of concentration of at least one selected component of the process gas; and process control means arranged to receive the output of the thermopile detector[10].

A thermopile detector for a temperature measuring instrument physically and electrically configured to supply an output signal which indicates a target temperature substantially independent of the influence of ambient temperature changes. The detector is comprised of a plurality of interleaved and electrically opposing thermocouples on a common surface of a substrate wherein the interleaved thermocouples are comprised of active thermocouples having a high emissivity coating to increase their sensitivity to infrared radiation and blind compensating thermocouples having a low emissivity coating to minimize their sensitivity to infrared radiation [11]

A thermopile type radiation detector for use in radiation pyrometer having small size and high performance in which the thermopiles are formed by evaporating the thermocouple leads onto a thin substrate together with a pattern distribution of thermocouple junctions that produces an output that is more representative of the distributed radiant energy impinging on the hot junctions of the thermopile. The thermopile performance is improved also by the incorporation of relatively large reflecting areas associated with the region of the thermopile where the cold junctions are located.

*3.3.3 Relay*

A relay is an electrical switch that opens and closes under the control of another electrical circuit. Referring to Figure 3, relay is used to trigger the alarm system and the emergency shutdown valve whenever the signal from detector circuit is transmitted. The simple circuit of relay circuit is shown in Figure 5.

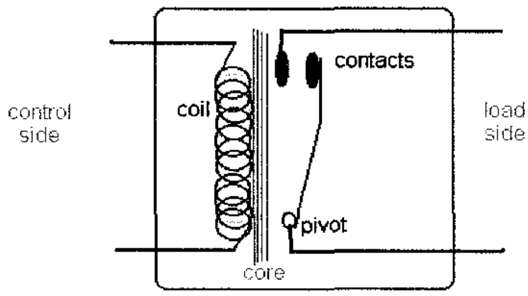


Figure 6 : Basic relay diagram

When an electric current is passed through the coil, the resulting magnetic field attracts the armature, and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position [12].

Example of relay is shown below :

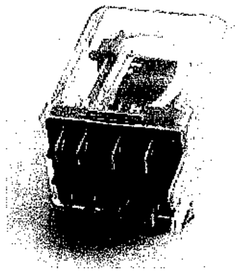

Figure 7 : AC Coil Relay (Ice Cube Packaging)

### 3.3.4 Alarm circuit

Alarm is a device that signals the occurrence of some undesirable event. When the alarm is triggered, it emits a loud sound designed to warn users of the leakage occurrence. Basic alarm system circuit is shown in Figure 8 below :

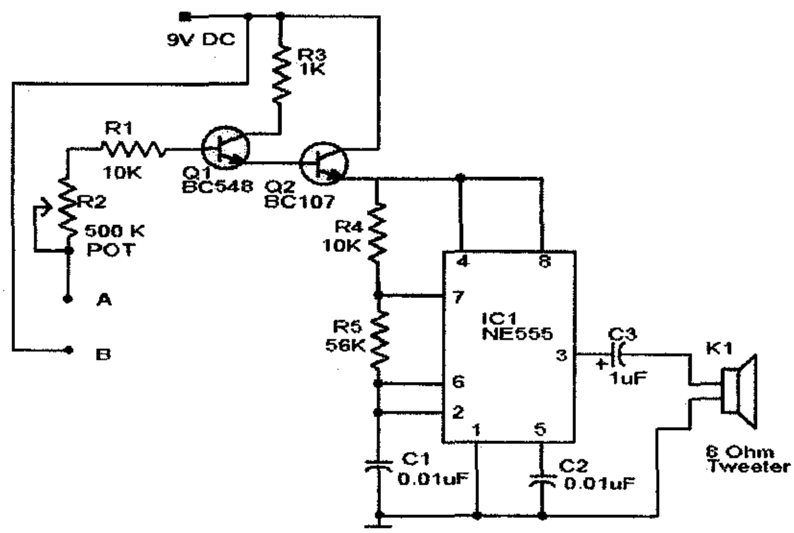


Figure 8 : Alarm System circuit Diagram

In this project, the buzzer will be used to emit sounds to alert users during leakage. A buzzer or beeper is a signaling device usually electronics, that is most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

### 3.4 Tools and Equipments Required

Table 1 : Tools Required for LPG Detection

| HARDWARE | SOFTWARE |
|---|---|
| ☐ IR circuit (transmitter, detector)<br>☐ LPG source<br>☐ A chamber<br>☐ Multimeter/ Oscilloscope<br>☐ Buzzer<br>☐ Relay | ☐ Multisim<br>☐ EAGLE<br>☐ PSPICE |

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Intergrated Infrared Circuit

Since infrared radiation has many advantages when used as a gas detector over the catalyst detector, one of the facts that student must know is the infrared source generates heat. the incandescent lamp is inappropriate to use as a gas leakage detector though it is one of the infrared light source since this project deals with the detection of combustible gas leakage.

The use of 555 timer circuit also is not suitable as it cannot produce a frequency of TeraHertz - a vibrational frequency desired to match with LPG molecule motion frequency. Therefore, student has replaced the I!C 555 Timer with IC LM741; an operational amplifier to amplifythe frequency generated. The circuit is then being shown as stated in the Figure 9 below:

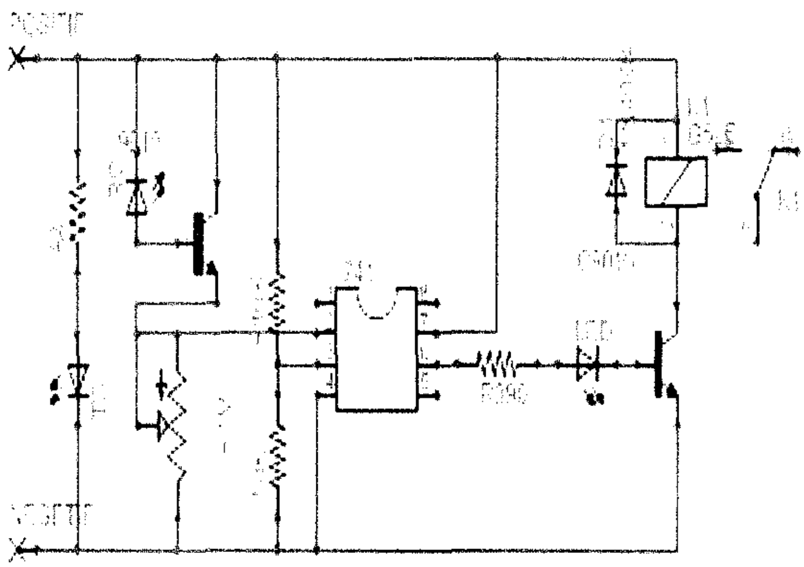

Figure 9: Infrared circuit (small view)

The circuit is first designed using EAGLE software, which is really needed in PCB fabrication. The 9V of power supply is used in the circuit work. R4 is used to limit the current flow towards the infrared emitter. If the voltage supply is 5V, the resistor is then changed into 390Ω. Since 9V supply is used, a 560Ω Resistor is placed for R4.The 9V of supply is chosen as it is easy to purchase in any hardware store.

The range of infrared transmission can be adjusted with the implementation of variable resistor in the circuit. The maximum range of detection can be as far as 1 meter. In this project, the prototype model is designed to detect the infrared radiation at a distance of 15 cm.

The LED is used as the indication of the absorption of infrared radiation. If the leakage has occurred and detected by the infrared receiver, the LED will be turned on or vice versa. Figure 10 below shows the construction of infrared circuit:

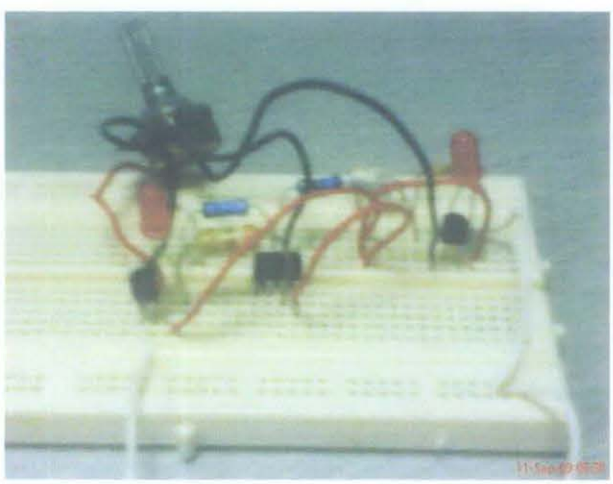

Figure 10: Infrared circuit construction

After this stage is done, the next stage is the PCB fabrication. Using the EAGLE software, the schematic of the circuit can be simplified to ease the soldering activity. This can be easily to understand in the Figure 11.

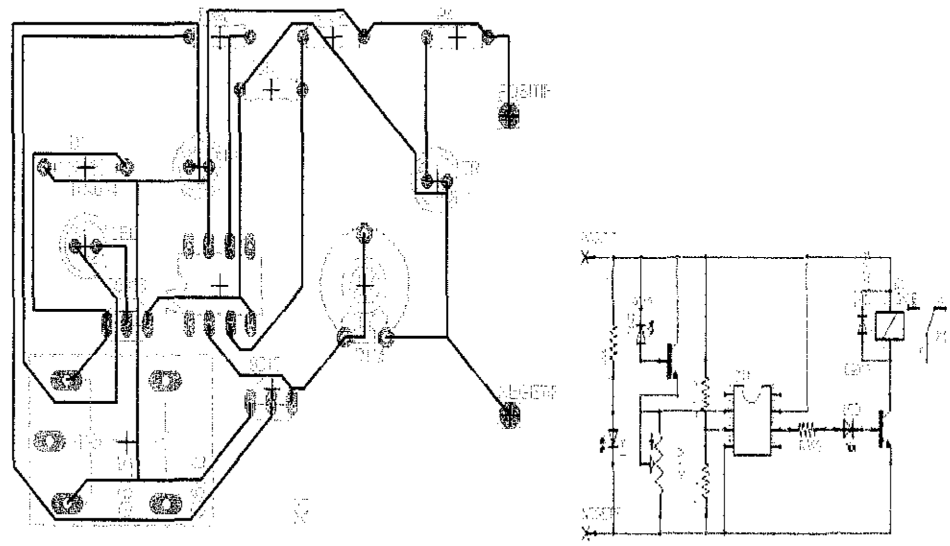

Figure 11: PCB circuit design and normal schematic design

## 4.2 LPG Experiment Result

In order to observe the voltage variation of the circuit, a diode and 100 ohm Resistor is place at the infrared LED receiver. This is for the purpose of smoothing the voltage and connecting the circuit to the oscilloscope.

The experiment is conducted in the confined area, thus the result is shown below:

**Output voltage when there is NO LPG leakage= 8.9V**

**Output voltage when there is an LPG Leakage= 7.8V**

The voltage reading is taken from the oscillator. From the graph obtained as shown in Figure 12, the time taken for the circuit to detect the leakage at the distance of 15 cm is 10 second. This is obviously shown when there was a sudden drop in the voltage after the LPG gas was released into the chamber. The voltage began to be at its steady state value when the LPG started to disperse in the surrounding which had reduced its concentration.

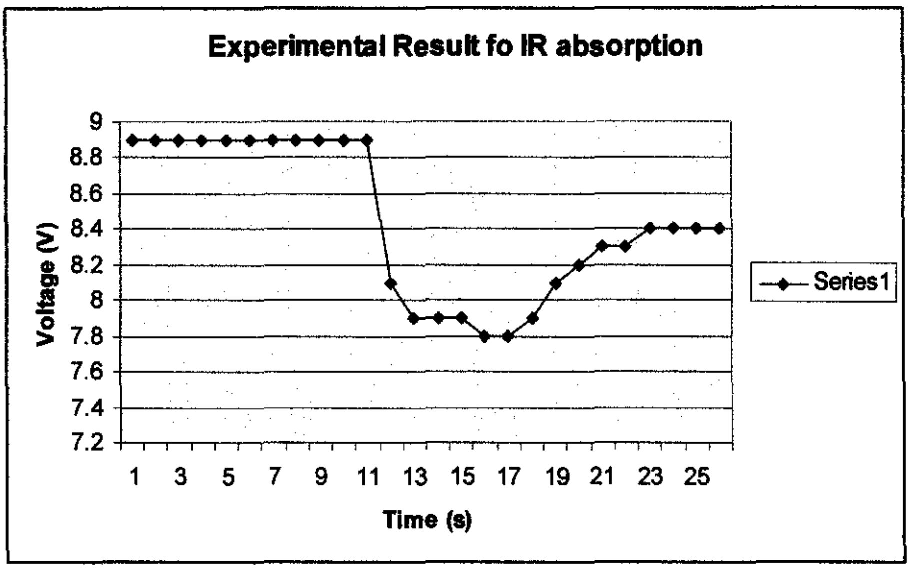


Figure 12: Experimental Result for IR Absorption

To monitor the circuit performance, the experiment is then repeated by varying the distance of the infrared transmission. The distance of the first attempt is 15 cm. The distance is then varied up until 40 cm to see the sensitivity of the circuit using the same concentration of LPG gas as shown in Figure 13.

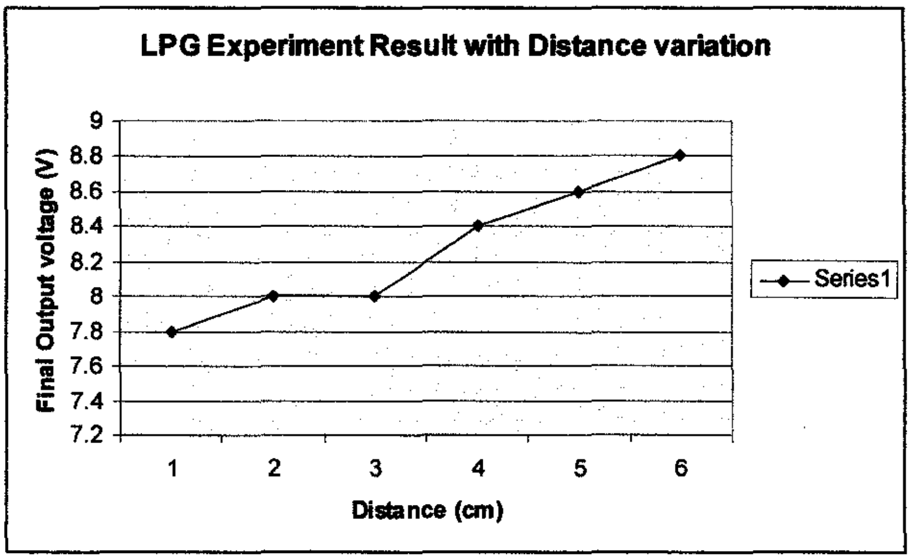


Figure 13: LPG Experiment Result with distance Variation

From this result, student can conclude that the greater the distance between Infrared Transmitter and receiver, the lesser the capability of the circuit to detect the leakage. As a result, the voltage drop difference will also decrease due to the increment in the final voltage drop. The relay will not be triggered as the detecting LED is not turned on.

### 4.3 Alarm Circuit and Triggering Relay

The relay is connected in parallel with the voltage supply. Therefore, as the 9V of supply is used, a 9V relay is chosen to make the relay operates as an electronic-switch. Normally-closed relay is to be put on the infrared detection circuit. The switch is basically closed and let the infrared detector circuit operated. Once the leakage had occurred, there will be a sudden drop of voltage making the switch of the relay to be automatically changed into the other position thus activating the alarm to turn on.

### 4.4 Gas Chamber

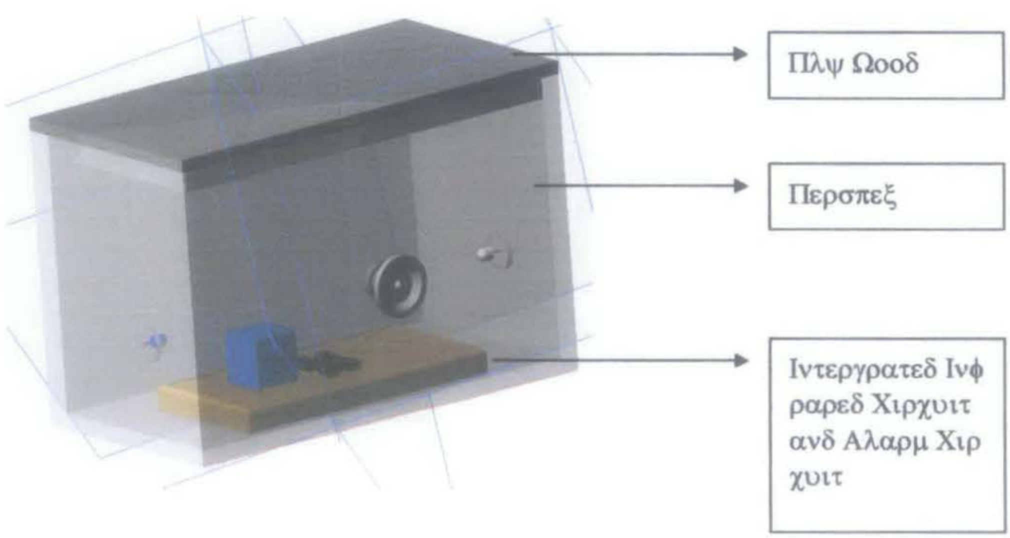


Figure 14: Gas Chamber

Figure 14 shows the 3D design of the prototype model. Some pieces of Perspex are used to provide invisibility through the chamber. This prospect is used because of the transparency, easy to cut and being joined together and air-proof material.

The ply wood is then used as a back-up if ever the PCB circuit is difficult to be pasted on the prospect. The student will screw the circuit onto this ply wood. Besides that, the dark colour of this ply wood will increase the visibility of the LED to observer as it can be easily to notice if the LED has turn on and blink for the alarm circuit.

#### 4.5 Detecting the Excessive of LPG Leakage

In order to enhance the level of safety detection, the circuit in Figure 9 has been modified to detect the excess of LPG leakage. LM 3194n is used to indicate the value of voltage that has dropped based on the absorption of LPG using the infrared radiation. The LM3914 is an integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. Figure 15 shows the configuration of IC LM 3914.

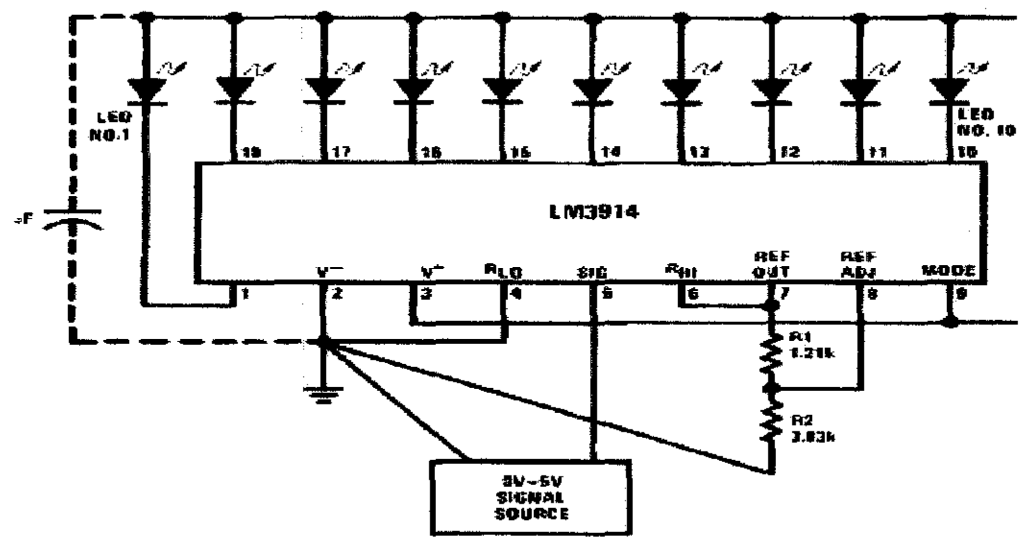


Figure 15: LM 3914 configuration

The circuit is then modified and previewed using the EAGLE software and the result is shown as in the Figure 16:

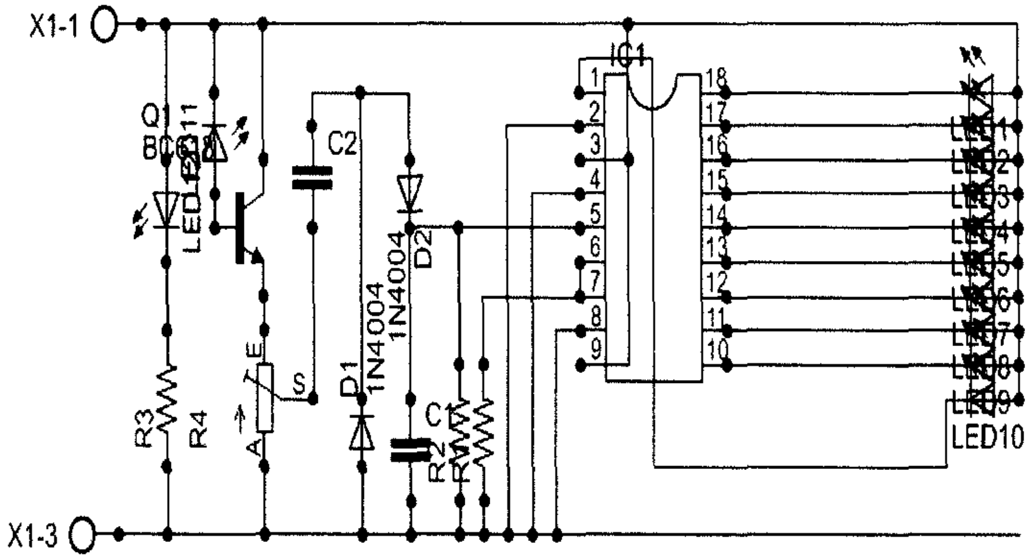


Figure 16: Enhancement of LPG detector circuit

10 LED are being used namely LED 1 up until LED 10 to indicate the value of voltage according to the absorption of LPG gas. LED 1 indicates the maximum voltage which means that only the minimum amount of LPG has leaked into the surrounding meanwhile LED 10 indicates that the maximum amount of LPG leakage has been leaked into the surrounding due to the minimum voltage has been measured by the IC LM 3914.

### 4.6 Advantage of Infrared in Detecting the Combustible Gas

Infrared technology is known for high reliability and simple installation. Of the many hydrocarbons that are found in industry today, most are detectable with a catalytic combustion sensor and many are detectable with an infrared sensor. It is important to consider the specific compounds to be monitored as there are some that do not readily lend themselves to detection with a general purpose infrared (IR) detector, such as hydrogen for example. For better explanation ,we will look at the basic principles of operation for infrared technologies.

The Infrared (IR) detection method is based upon the absorption of infrared radiation at specific wavelengths as it passes through a volume of gas. Typically two infrared light sources and an infrared light detector measures the intensity of two different wavelengths, one at the absorption wavelength and one outside the absorption wavelength. If a gas intervenes between the source and the detector, the level of radiation falling on the detector is reduced. Gas concentration is determined by comparing the relative values between the two wavelengths. This is a dual beam infrared detector.

Infrared gas detection is based upon the ability of some gases to absorb IR radiation. Many hydrocarbons absorb IR at approximately 3.4 micrometers. As mentioned earlier, there are some hydrocarbons and other flammable gases that have poor or no response on a general purpose IR sensor. In addition to aromatics and acetylene, hydrogen, ammonia and carbon monoxide also cannot be detected using IR technology with general purpose sensors of 3.4 micron specifications.

"The major advantages of IR gas detectors:

- ☐ Immunity to contamination and poisoning.
- ☐ Consumables (source and detector) tend to outlast catalytic sensors.
- ☐ Can be calibrated less often than a catalytic detector.
- ☐ Ability to operate in the absence of oxygen or in enriched oxygen.
- ☐ Ability to operate in continuous presence of gas.
- ☐ Can perform more reliably in varying flow conditions.
- ☐ Even when flooded with gas, will continue to show high reading and sensor will not be damaged" [13]

# CHAPTER 5

# CONCLUSION AND RECOMENDATION

## 5.1 Conclusion

When designing a combustible gas safety monitoring system for oil and gas petrochemical or other application, a thorough analysis of application's unique field environment is needed to ensure optimal performance, safety, reliability and cost-effectiveness. A quick decision, of course, can lead to poor detector choices as well as safety, performance, maintenance, and life-cycle cost consequences. As student is doing continuous research on infrared technologies and its application, she believes that gas detection method using infrared is one of reliable method to be used as a precaution to danger that can be caused by gas leakage. The implementation of automated safety systems such as shutdown valve and alarm system will enhance the effectiveness of this method to users.

The integrated infrared circuit has been constructed and tested until this period of time. Future works that has to be done in this project is to fabricate the gas chamber as well as combining the alarm circuit into the integrated infrared circuit. The analysis to measure the reliability of the infrared circuit also has to be improvised so that this gas detector become immune to any eternal noise and errors.

## 5.2 Recommendation

For improvement in the future, some additional feature could be added in order to make increase the performance and capability of the circuit. Some recommendations are briefly explained below:

### *5.2.1 Various Gas Detection*

This model can only detect various combustible gasses at certain distance. By applying the theory of infrared absorption, gassed like Sulphur, carbon Monoxide, Nitrogen Dioxide and other gasses which are toxic and poisonous can only be detected by infrared at certain wavelength. The future improvement of this project will help to improve the functionality of this model

### *5.2.2 Performance of the circuit*

When the LPG has dispersed into the surrounding, its concentration will be decreased. Therefore, this model will not be able to detect the leakage appropriately. The design of this model has to be improved so that it can detect the leakage just as the leakage had occurred.

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[5]http://images.google.com/imgres?imgurl=http://media.guelphmercury.topscms.com/images/c2/7e/bc06e4d24abbb91e40c8c838ae27.jpeg&imgrefurl=http://news.guelphmercury.com/News/article/303478&usg=__jJjHmvbe5h3v_pjQld9V6hK_KQE=&h=275&w=406&sz=31&hl=en&start=136&sig2=aLrUtXUmrEqibu1RUB76_A&um=1&tbnid=A0BSitadZtbggM:&tbnh=84&tbnw=124&prev=/images%3Fq%3Dgas%2Bleakage%2Baccident%26ndsp%3D20%26hl%3Den%26rlz%3D1G1GGLQ_ENMY308%26sa%3DN%26start%3D120%26um%3D1&ei=_qnmSeHLG6bo6gOT9PzUAw

[6] **http://www.encyclopedia.com/doc/1E1-infrared.html**

[7] http://www.highbeam.com/doc/1G1-20487005.html

[8] http://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/irspec1.htm

[9] http://www.e-lpg.com/lp_gas_faqgen.asp

[10] 5Fitriah bt Shafe'I,"*Gas Leakage Detection System Using Infrared (IR) Radiation*",June 2007

[11] http://www.freepatentsonline.com/4111717.html

[12] **http://www.jag-lovers.org/lumps/tech/basics/spst_relay.gif**

# APPENDIX A

# LM 741 OPERATIONAL AMPLIFIER

FAIRCHILD SEMICONDUCTOR

February 2007

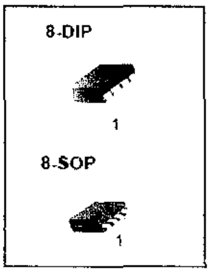
## LM741
## Single Operational Amplifier

### Features

- Short Circuit Protection
- Excellent Temperature Stability
- Internal Frequency Compensation
- High Input Voltage Range
- Null of Offset

### Description

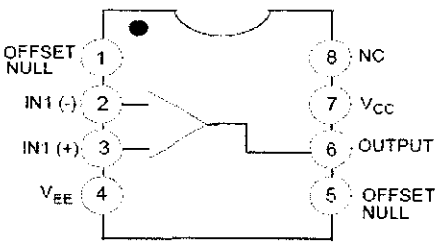
The LM741 series are general purpose operational amplifiers. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in intergrator, summing amplifier, and general feedback applications.



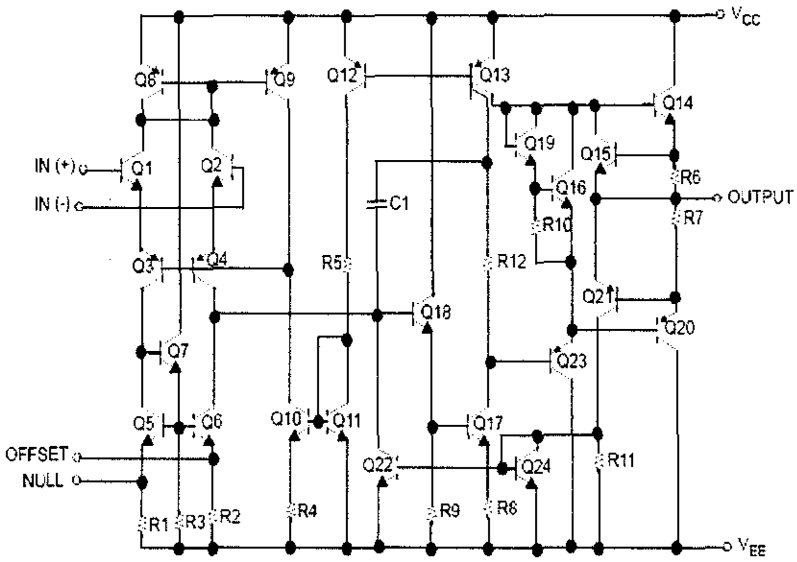

### Ordering Information

| Part Number | Operating Temp. Range | Pb-Free | Package | Packing Method | Marking Code |
|---|---|---|---|---|---|
| LM741CN | 0 ~ +70°C | YES | 8-DIP | Rail | LM741CN |
| LM741CM | | YES | 8-SOP | Rail | LM741CM |
| LM741CMX | | YES | 8-SOP | Tape & Reel | LM741CM |

### Internal Block Diagram



## Schematic Diagram




## Absolute Maximum Ratings

The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. $T_A$=25°C, unless otherwise specified.

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply Voltage | ±18 | V |
| $V_{I(DIFF)}$ | Differential Input Voltage | 30 | V |
| $V_I$ | Input Voltage | ±15 | V |
| - | Output Short Circuit Duration | Indefinite | - |
| $P_D$ | Power Dissipation | 500 | mW |
| $T_{OPR}$ | Operating Temperature Range | 0 ~ +70 | °C |
| $T_{STG}$ | Storage Temperature Range | -65 ~ +150 | °C |

## Electrical Characteristics

($V_{CC}$ = 15V, $V_{EE}$ = -15V, $T_A$ = 25°C, unless otherwise specified)

| Parameter | Symbol | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{IO}$ | $R_S \le 10k\Omega$ | | - | 2.0 | 6.0 | mV |
| | | $R_S \le 50\Omega$ | | - | - | - | |
| Input Offset Voltage Adjustment Range | $V_{IO(R)}$ | $V_{CC} = \pm 20V$ | | - | ±15 | - | mV |
| Input Offset Current | $I_{IO}$ | - | | - | 20 | 200 | nA |
| Input Bias Current | $I_{BIAS}$ | - | | - | 80 | 500 | nA |
| Input Resistance (Note1) | $R_I$ | $V_{CC} = \pm 20V$ | | 0.3 | 2.0 | - | MΩ |
| Input Voltage Range | $V_{I(R)}$ | - | | ±12 | ±13 | - | V |
| Large Signal Voltage Gain | $G_V$ | $R_L \ge 2k\Omega$ | $V_{CC} = \pm 20V$, $V_{O(P-P)} = \pm 15V$ | - | - | - | V/mV |
| | | | $V_{CC} = \pm 15V$, $V_{O(P-P)} = \pm 10V$ | 20 | 200 | - | |
| Output Short Circuit Current | $I_{SC}$ | - | | - | 25 | - | mA |
| Output Voltage Swing | $V_{O(P-P)}$ | $V_{CC} = \pm 20V$ | $R_L \ge 10k\Omega$ | - | - | - | V |
| | | | $R_L \ge 2k\Omega$ | - | - | - | |
| | | $V_{CC} = \pm 15V$ | $R_L \ge 10k\Omega$ | ±12 | ±14 | - | |
| | | | $R_L \ge 2k\Omega$ | ±10 | ±13 | - | |
| Common Mode Rejection Ratio | CMRR | $R_S \le 10k\Omega$, $V_{CM} = \pm 12V$ | | 70 | 90 | - | dB |
| | | $R_S \le 50\Omega$, $V_{CM} = \pm 12V$ | | - | - | - | |
| Power Supply Rejection Ratio | PSRR | $V_{CC} = \pm 15V$ to $V_{CC} = \pm 15V$, $R_S \le 50\Omega$ | | - | - | - | dB |
| | | $V_{CC} = \pm 15V$ to $V_{CC} = \pm 15V$, $R_S \le 10k\Omega$ | | 77 | 96 | - | |
| Transient Response: Rise Time | $T_R$ | Unity Gain | | - | 0.3 | - | μs |
| Transient Response: Overshoot | OS | | | - | 10 | - | % |
| Bandwidth | BW | - | | - | - | - | MHz |
| Slew Rate | SR | Unity Gain | | - | 0.5 | - | V/μs |
| Supply Current | $I_{CC}$ | $R_L = \infty\Omega$ | | - | 1.5 | 2.8 | mA |
| Power Consumption | $P_C$ | $V_{CC} = \pm 20V$ | | - | - | - | mW |
| | | $V_{CC} = \pm 15V$ | | - | 50 | 85 | |

**Note:**
1. Guaranteed by design.

## Electrical Characteristics (Continued)

( 0°C ≤ $T_A$ ≤ 70 °C, $V_{CC}$ = ±15V, unless otherwise specified)
The following specification apply over the range of 0°C ≤ $T_A$ ≤ +70°C for the LM741C

| Parameter | Symbol | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{IO}$ | $R_S$ ≤ 50Ω | | - | - | - | mV |
| | | $R_S$ ≤ 10kΩ | | - | - | 7.5 | |
| Input Offset Voltage Drift | $\Delta V_{IO}/\Delta T$ | - | | - | - | | µV/°C |
| Input Offset Current | $I_{IO}$ | - | | - | - | 300 | nA |
| Input Offset Current Drift | $\Delta I_{IO}/\Delta T$ | - | | - | - | | nA/°C |
| Input Bias Current | $I_{BIAS}$ | - | | - | - | 0.8 | µA |
| Input Resistance (Note1) | $R_I$ | $V_{CC}$ = ±20V | | - | - | - | MΩ |
| Input Voltage Range | $V_{I(R)}$ | - | | ±12 | ±13 | - | V |
| Output Voltage Swing | $V_{O(P-P)}$ | $V_{CC}$ =±20V | $R_S$ ≥ 10kΩ | - | - | - | V |
| | | | $R_S$ ≥ 2kΩ | - | - | - | |
| | | $V_{CC}$ =±15V | $R_S$ ≥ 10kΩ | ±12 | ±14 | - | |
| | | | $R_S$ ≥ 2kΩ | ±10 | ±13 | - | |
| Output Short Circuit Current | $I_{SC}$ | - | | 10 | - | 40 | mA |
| Common Mode Rejection Ratio | CMRR | $R_S$ ≤ 10kΩ, $V_{CM}$ = ±12V | | 70 | 90 | - | dB |
| | | $R_S$ ≤ 50Ω, $V_{CM}$ = ±12V | | - | - | - | |
| Power Supply Rejection Ratio | PSRR | $V_{CC}$ = ±20V to ±5V | $R_S$ ≤ 50Ω | - | - | - | dB |
| | | | $R_S$ ≤ 10kΩ | 77 | 96 | - | |
| Large Signal Voltage Gain | $G_V$ | $R_S$ ≥ 2kΩ | $V_{CC}$ = ±20V, $V_{O(P-P)}$ = ±15V | - | - | - | V/mV |
| | | | $V_{CC}$ = ±15V, $V_{O(P-P)}$ = ±10V | 15 | - | - | |
| | | | $V_{CC}$ = ±15V, $V_{O(P-P)}$ = ±2V | - | - | - | |

**Note :**

1. Guaranteed by design.

## Typical Performance Characteristics

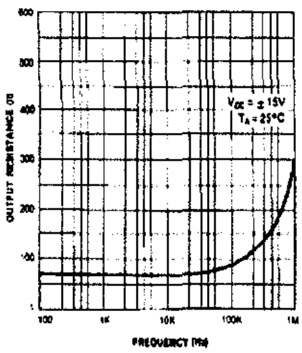



Figure 1. Output Resistance vs Frequency

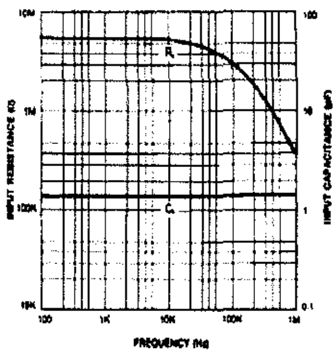


Figure 2. Input Resistance and Input Capacitance vs Frequency

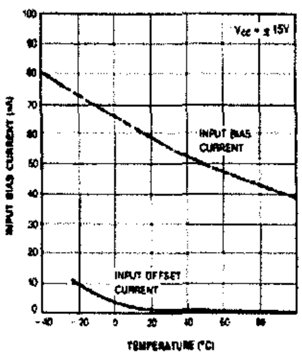



Figure 3. Input Bias Current vs Ambient Temperature

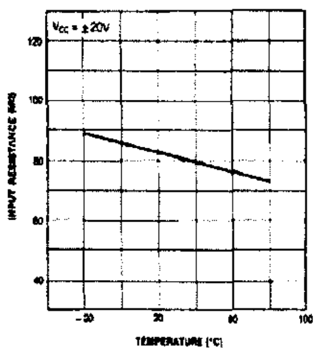



Figure 4. Power Consumption vs Ambient Temperature

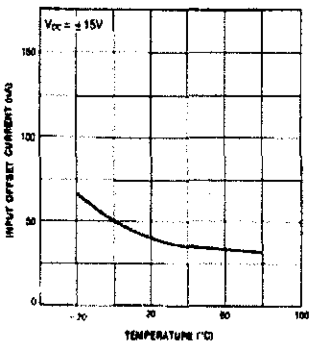



Figure 5. Input Offset Current vs Ambient Temperature

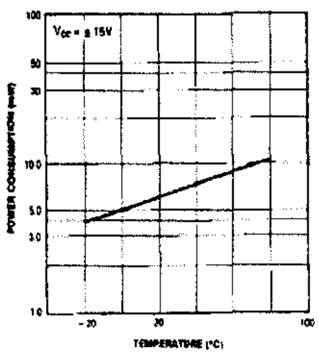



Figure 6. Input Resistance vs Ambient Temperature

## Typical Performance Characteristics (Continued)

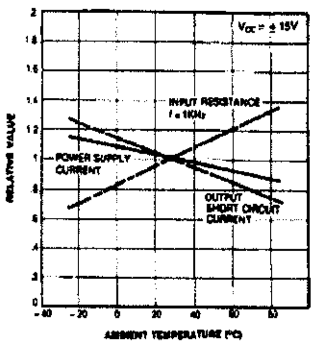



Figure 7. Normalized DC Parameters vs Ambient Temperature

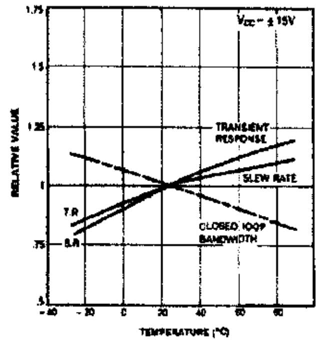



Figure 8. Frequency Characteristics vs Ambient Temperature

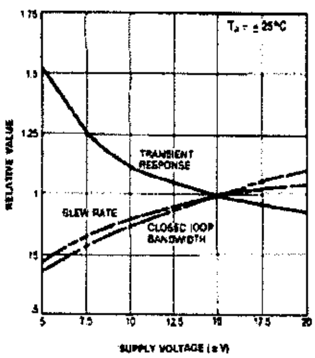



Figure 9. Frequency Characteristics vs Supply Voltage

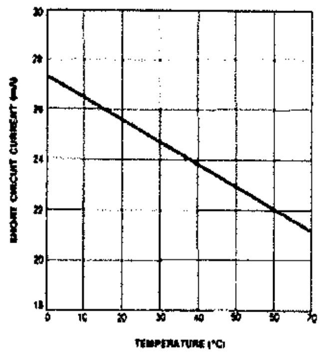



Figure 10. Output Short Circuit Current vs Ambient Temperature

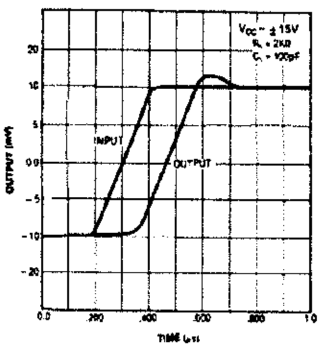



Figure 11. Transient Response

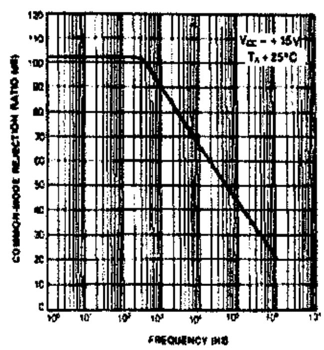



Figure 12. Common-Mode Rejection Ratio vs Frequency

## Typical Performance Characteristics (Continued)

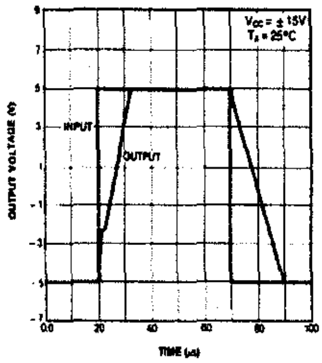



Figure 1. Voltage Follower Large Signal Pulse Response

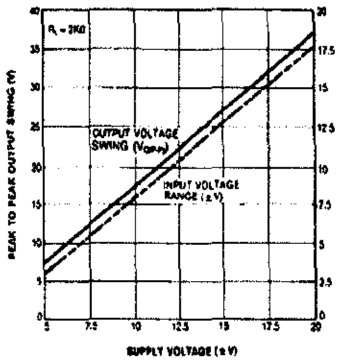
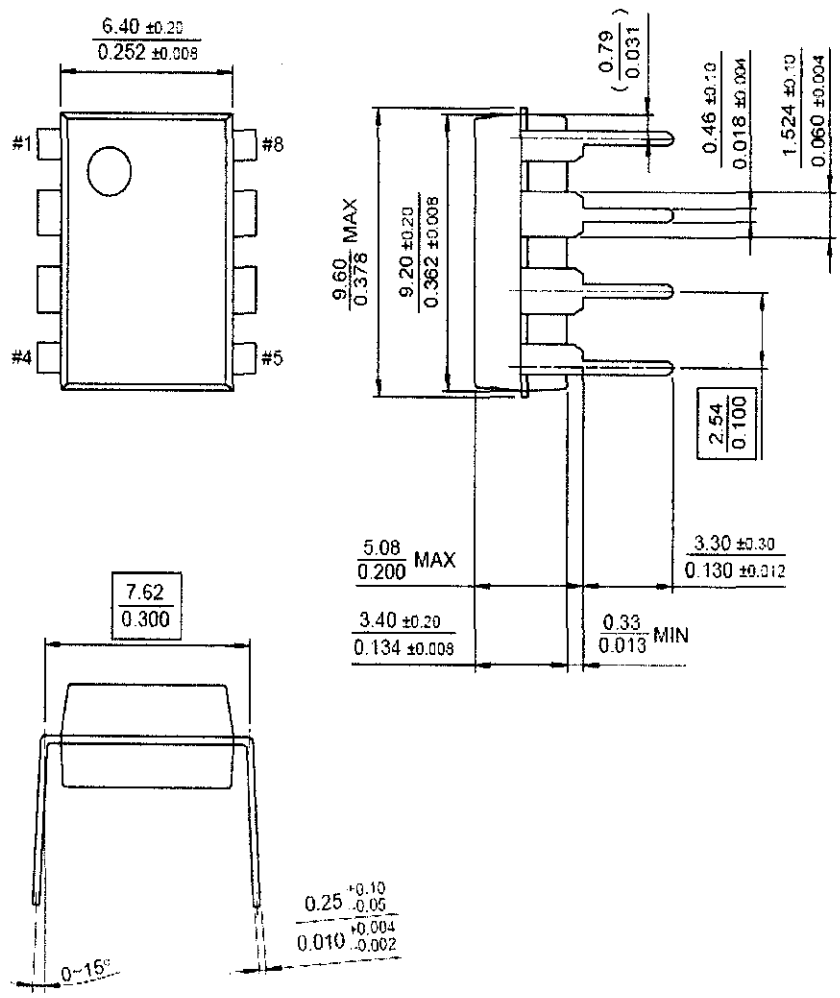



Figure 2. Output Swing and Input Range vs Supply Voltage

**Package**

**Dimensions in millimeters**

# 8-DIP

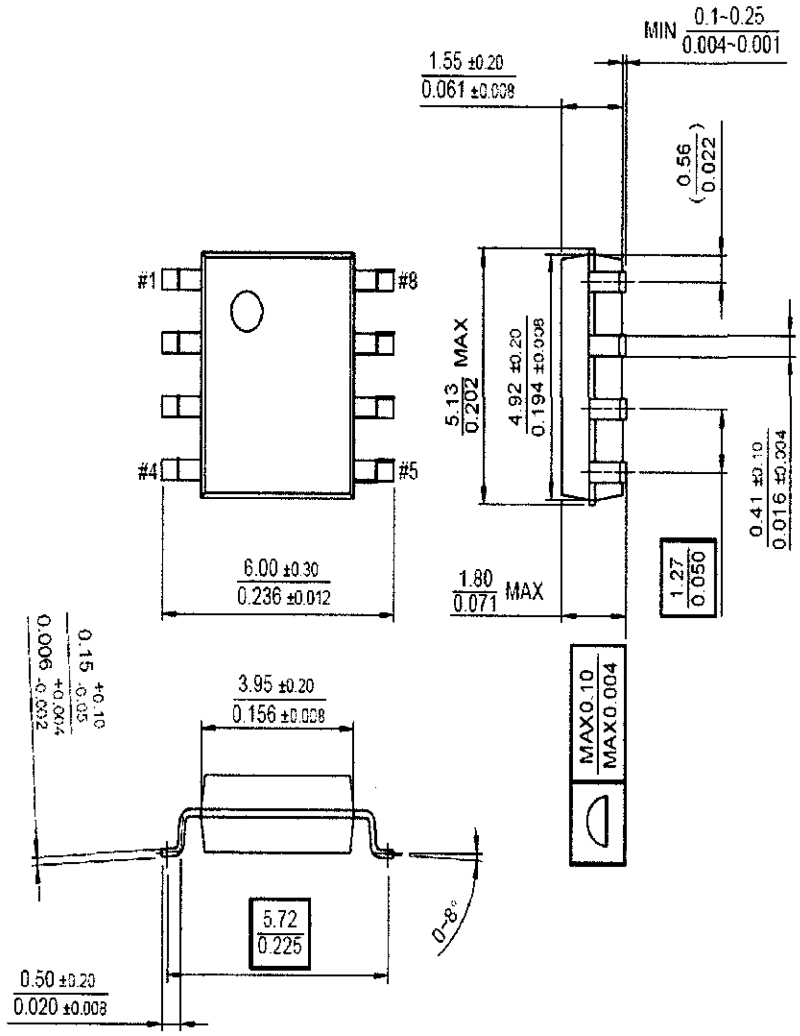


## Mechanical Dimensions (Continued)

### Package

**Dimensions in millimeters**

## 8-SOP



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

| Datasheet Identification | Product Status | Definition |
|---|---|---|
| Advance Information | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice. |
| Preliminary | First Production | This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design. |
| No Identification Needed | Full Production | This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design. |
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Rev. I2

# APPENDIX B

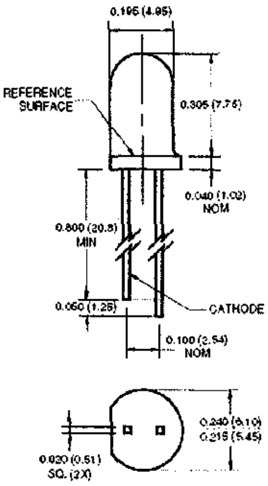
# PLASTIC INFRARED LED

FAIRCHILD
SEMICONDUCTOR®

## PLASTIC INFRARED LIGHT EMITTING DIODE

**QED233** **QED234**

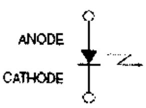
### PACKAGE DIMENSIONS




NOTES:

1. Dimensions for all drawings are in inches (mm).
2. Tolerance of ± .010 (.25) on all non-nominal dimensions unless otherwise specified.

### SCHEMATIC




## DESCRIPTION

The QED233 / QED234 is a 940 nm GaAs / AlGaAs LED encapsulated in a clear untinted, plastic T-1 3/4 package.

## FEATURES

- λ= 940 nm
- Chip material =GaAs with AlGaAs window
- Package type: T-1 3/4 (5mm lens diameter)
- Matched Photosensor: QSD122/123/124
- Medium Emission Angle, 40°
- High Output Power
- Package material and color: Clear, untinted, plastic
- Ideal for remote control applications

FAIRCHILD SEMICONDUCTOR®

# PLASTIC INFRARED LIGHT EMITTING DIODE

## QED233 QED234

| ABSOLUTE MAXIMUM RATINGS ($T_A$ = 25°C unless otherwise specified) | | | |
|---|---|---|---|
| **Parameter** | **Symbol** | **Rating** | **Unit** |
| Operating Temperature | $T_{OPR}$ | -40 to +100 | °C |
| Storage Temperature | $T_{STG}$ | -40 to +100 | °C |
| Soldering Temperature (Iron)[2,3,4] | $T_{SOL-I}$ | 240 for 5 sec | °C |
| Soldering Temperature (Flow)[2,3] | $T_{SOL-F}$ | 260 for 10 sec | °C |
| Continuous Forward Current | $I_F$ | 100 | mA |
| Reverse Voltage | $V_R$ | 5 | V |
| Power Dissipation[1] | $P_D$ | 200 | mW |
| Peak Forward Current | $I_{FP}$ | 1.5 | A |

1. Derate power dissipation linearly 2.67 mW/°C above 25°C.
2. RMA flux is recommended.
3. Methanol or isopropyl alcohols are recommended as cleaning agents.
4. Soldering iron 1/16" (1.6mm) minimum from housing.
5. Pulse conditions; tp = 100 μs, T = 10 ms.

| ELECTRICAL / OPTICAL CHARACTERISTICS ($T_A$ =25°C) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITIONS** | **DEVICE** | **SYMBOL** | **MIN** | **TYP** | **MAX** | **UNITS** |
| Peak Emission Wavelength | $I_F$ = 20 mA | ALL | $\lambda_{PE}$ | — | 940 | — | nm |
| Spectral Bandwidth | $I_F$ = 20 mA | ALL | — | 50 | — | nm | |
| Temp. Coefficient of $\lambda_{PE}$ | $I_F$ = 100 mA | ALL | $TC_\lambda$ | — | 0.2 | — | nm/K |
| Emission Angle | $I_F$ = 100 mA | ALL | $2\Theta_{1/2}$ | — | 40 | — | Deg. |
| Forward Voltage | $I_F$ = 100 mA, tp = 20 ms | ALL | $V_F$ | — | — | 1.6 | V |
| Temp. Coefficient of $V_F$ | $I_F$ = 100 mA | ALL | $TC_V$ | — | -1.5 | — | mV/K |
| Reverse Current | $V_R$ = 5 V | ALL | $I_R$ | — | — | 10 | μA |
| Radiant Intensity | $I_F$ = 100 mA, tp = 20 ms | QED233 | $I_E$ | 10 | — | 50 | mW/sr |
| | | QED234 | | 27 | — | — | |
| Temp. Coefficient of $I_E$ | $I_F$ = 20 mA | ALL | $TC_I$ | — | -0.6 | — | %/K |
| Rise Time | $I_F$ = 100 mA | ALL | $t_r$ | — | 1000 | — | ns |
| Fall Time | | ALL | $t_f$ | — | 1000 | — | |

# PLASTIC INFRARED LIGHT EMITTING DIODE

## QED233 QED234

### TYPICAL PERFORMANCE CURVES TBD

**Fig. 1 Normalized Radiant Intensity vs. Forward Current**

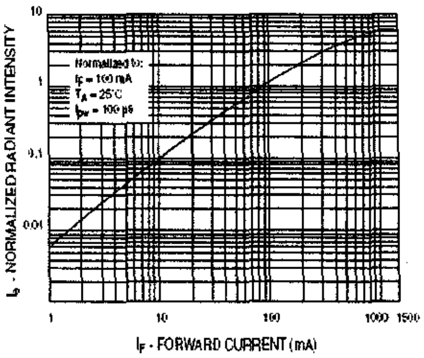



**Fig. 2 Forward Voltage Vs. Ambient Temperature**

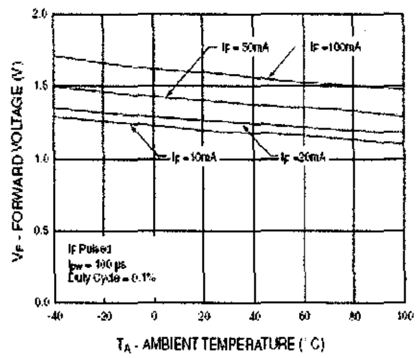



**Fig. 3 Normalized Radiant Intensity vs. Wavelength**

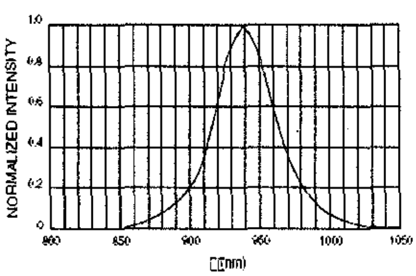



**Fig. 4 Radiation Diagram**

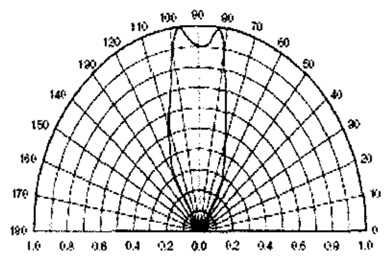
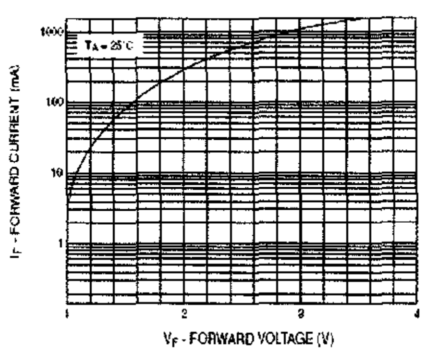


**Fig. 5 Forward Current vs. Forward Voltage**



# PLASTIC INFRARED LIGHT EMITTING DIODE

## QED233 QED234

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FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body,or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in labeling, can be reasonably expected to result in a significant injury of the user.

2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# APPENDIX C
## CIRCUIT CONSTRUCTION